

A morphological gap for Iberian *Zospeum* filled: *Zospeum percostulatum* sp. n. (Gastropoda, Eupulmonata, Carychiidae) a new species from Asturias (Spain)

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Abstract

Zospeum percostulatum **sp. n.** from Cueva de La Herrería (Llanes, Asturias) is described. It is characterized by a relatively large shell (1.4–1.8 mm height), conical, with ovate aperture, continuous peristome and thickened parietal callus; shell costulate except two first whorls; without any sort of inner formations. It is the first clearly costulate Iberian species, filling a morphological gap in the Iberian clade, and the largest species from the Cantabrian region, being the first species described from Asturias.

Keywords

Cave-dwelling species, troglobiont gastropod, microgastropod, shell variability, ecology

Resumen

Se describe *Zospeum percostulatum* **sp. n.** de la Cueva de La Herrería (Llanes, Asturias), caracterizada por una concha relativamente grande (1.4–1.8 mm de longitud), cónica, con abertura ovalada, peristoma continuo y callo parietal engrosado; superficie costulada excepto en las dos primeras vueltas y carente de cualquier rastro de formaciones internas. Es la primera especie ibérica nítidamente costulada, lo que llena un hueco morfológico del clado ibérico, y la de mayor tamaño de la región cantábrica, y es la primera especie descrita de Asturias.

Palabras clave

Especie cavernícola, gasterópodo troglobio, microgasterópodo, variabilidad conchológica, ecología

Introduction

The genus *Zospeum* Bourguignat, 1856 is the only troglobiont genus of land snails present in the Iberian Peninsula, and has also been for a long time the only troglobiont genus of the family Carychiidae until the recent description of the genus *Koreozospeum* (Jochum et al. 2015a). The geographical distribution comprises two disjunct areas: eastern Alps and Dinaric Alps from where about twenty species are known (Bole 1974; Pezzoli 1992; Slapnik and Ozimec 2004; Weigand 2013; Jochum et al. 2015b), and the Pyrenean-Cantabrian region from where six species have been described so far. The first Iberian species described was *Zospeum schaufussi* Frauenfeld, 1862, collected inside an unknown Spanish cave by L. Schaufuss and briefly described with 16 words (Frauenfeld 1862). Unaware of the occurrence of any *Zospeum* species in western Europe, Gittenberger (1973) attributed the novelty to *Zospeum bellesi* Gittenberger, 1973, from the Cueva de Aso (northern part of Huesca province). Realizing that *Zospeum* is more widely distributed than in the Pyrenees, Gittenberger (1980) revised new Iberian material and the type material of *Z. schaufussi*, revalidating the already known species and further describing *Zospeum suarezi* Gittenberger, 1980 from a cave in Puente Viesgo (Cantabria) and other Cantabrian caves. Gómez and Prieto (1985) described *Zospeum biscaiense*, an odd toothed species from Cueva de Otxas in Yurre (Bizkaia), and more recently Jochum et al. (2015c) have described *Zospeum vasconicum* Prieto, De Winter, Weigand, Gómez & Jochum, 2015 from several caves from Bizkaia and Gipuzkoa provinces, and *Zospeum zaldivarae* Prieto, De Winter, Weigand, Gómez & Jochum, 2015 from Cueva de Las Paúles in Berberana (Burgos). Meanwhile, Weigand et al. (2013) had already demonstrated the molecular divergence between those two species and four genetic lineages conchologically grouped under *Zospeum suarezi*, thus evidencing that the biodiversity in the Cantabrian region is still far from completion.

Although based on an incomplete species sampling, both Alpine-Dinaric and Cantabrian species groups of *Zospeum* have been recovered as monophyletic sister clades (Weigand et al. 2013), but no morphological synapomorphies have been found for any of them. With respect to the Pyrenean-Cantabrian clade, a wider morphospace in the Alpine-Dinaric clade is evident, as exposed by Kobelt (1898, pl. 218–219) or Bole (1974), with small to large (up to 2.5 mm height), globose to slender, round to widely auriculate aperture, edentate to heavily toothed, smooth to ribbed species. On the contrary, Iberian diversity is restricted to smaller (less than 2mm), smooth, edentate species, with the only exception of the dentate *Z. biscaiense*.

The finding of a population with sharply costulated and relatively large shells allow us to describe it as a new species, since all known Iberian species have smooth shells, and only in one of the Cantabrian species, *Z. zaldivarae*, shells reach 1.6 mm in height (Jochum et al. 2015c).

Material and methods

The material studied has been gathered up mainly by flotation of fully desiccated clay sediments collected at the foot or holes of the walls where white, empty shells, have been detected. Shredded sediment was sieved through a fine mesh, then submerged in water, so most part of intact shells, together with organic remains, passes to the flotsam due to the formation of a bubble air inside them. Live individuals have also been collected through direct search on concretionated cave walls covered by a wet film of percolated clay.

SEM photographs were obtained with a Quanta 200 microscope; the other photographs are combined images produced through the Heliconfocus v.6.7.1 software from series of photographs obtained with a Nikon DS5M camera mounted on a stereomicroscope Nikon SMZ-1500. Shell measurements were done using the image analysis software of the Nikon DS5M camera. The analysis of the measurements was done with the PAST software (Hammer 2017) and the distribution map with the DMAPW software (Morton 2004).

Abbreviations

Public institutions:

MNCN Museo Nacional de Ciencias Naturales, Madrid.

MHNS Museo de Historia Natural, Universidad de Santiago de Compostela, Santiago de C.

ZUPV Colección del Departamento de Zoología, Universidad del País Vasco, Bilbao.

Private collections:

CAA Colección Álvaro Alonso.

CSQS Colección Sergio Quiñonero-Salgado.

Systematics

Family Carychiidae Jeffreys, 1830

Genus *Zospeum* Bourguignat, 1856

Type species. *Carychium spelaeum* Rossmässler, 1839 (Bourguignat 1856, orig. des.)

***Zospeum percostulatum* sp. n.**

<http://zoobank.org/9E01B0C5-FF3E-413C-B41C-6D2F07043AB9>

Type locality. Cueva de La Herrería (also known as Las Herrerías or La Mina) (43°23.98'N, 4°45.95'W, 30TUP5700006726, 45 m), La Pereda village, municipality

of Llanes (Asturias) (Fig. 1). The cave has a wide entrance, 2.5 m high, forming a deep shelter, continued by a short gallery on the left, about 20 m long, that leads to a series of small chambers, with height decreasing towards the end to less than 1 m. Most of the right side of the cave is labyrinthic and, because of its low height and the density of columns, some parts are almost impenetrable. Descending south-west from the smaller secondary entrance, there is a large (but quite low) diamond shaped chamber with four openings. To the south, this chamber leads to a long gallery with signs of sporadic hydraulic activity. To the west, protected by a fence, there is a chamber where one of the few samples of not figurative prehistoric painting in the north of Spain can be found, consisting of red grills made by parallel lines enclosed in a quadrangular contour, but lacking any signs of animal figuration (Jordà and Mallo 1972).

This cave was firstly named as Cueva de Bolao by Jeannel and Racovitza (1915) in their account of the exploration made in 1913 by the archaeologist H. Breuil. Cueva El Bolao was treated in some works as a nearby -but different- cave. Our explorations on the surroundings of La Herrería seem to confirm the suspicion of Bolívar (1923), who first pointed that El Bolao and La Herrería may be just two different names of a single cavity.

Type material. Holotype, a complete specimen (in ethanol 96°) [MNCN 15.05/200017H, ex ZUPV-4885], 18.07.2017, Á. Alonso, C. Prieto, S. Quiñonero-Salgado, J. Ruiz-Cobo leg.

Paratypes: 16 adult shells and 5 complete specimens [ZUPV-4885]; 50 adult shells [ZUPV-4913]; 30 adult shells [CAA-0737-A]; 25 adult shells [CSQS]. Paratypes from the sample ZUPV-4914 will be housed also in MNCN [15.05/200017P], Naturhistorisches Museum Wien and Naturalis Biodiversity Center.

Other material. 40 adult shells [ZUPV-4863]: Cueva Collubina (43°23.94'N, 4°43.37'W, 30TUP6048806568, 45 m), San Roque del Acebal, municipality of Llanes (Asturias), 18.07.2017, Á. Alonso, C. Prieto, S. Quiñonero-Salgado, J. Ruiz-Cobo leg.

Diagnosis. Species characterized by a relatively large shell, if compared to other Spanish *Zospeum* species, raised spire, ribbed surface, ovate opening, continuous peristome and absence of apertural teeth or internal lamellae.

Description (Figs 2–4). Shell 1.4–1.8 mm in length, fragile, hyaline when fresh, elongate to conic-ovate in smaller shells, with spire formed by 5–5.75 whorls. Protoconch (Figs 2F, 3B–D) rounded, somewhat globose, apparently smooth, with a small core and a very wide first half whorl, with a smooth surface that extends for a little more than a whorl, reaching a diameter of 0.4 mm. At high magnification it can be seen that the shell surface is full of spirally aligned small depressions formed by dots or short lines (Fig. 3C–D).

Teleoconch has about four well convex whorls, slightly shouldered and separated by a deep suture. These whorls present a sculpture of prosocline, narrow, sharp ribs with a rounded profile, somewhat irregularly arranged and sometimes incomplete, without reaching the inferior suture; its number and robustness increases every whorl and in the last one it can be 50 or more (8–10/0.5 mm).

Last whorl is near 60 % of the shell height, a bit more in smaller shells, barely and progressively ascending towards the aperture, where the rear ribs are somewhat closer together. Aperture ovoid, somewhat oblique, with almost vertical columellar border,

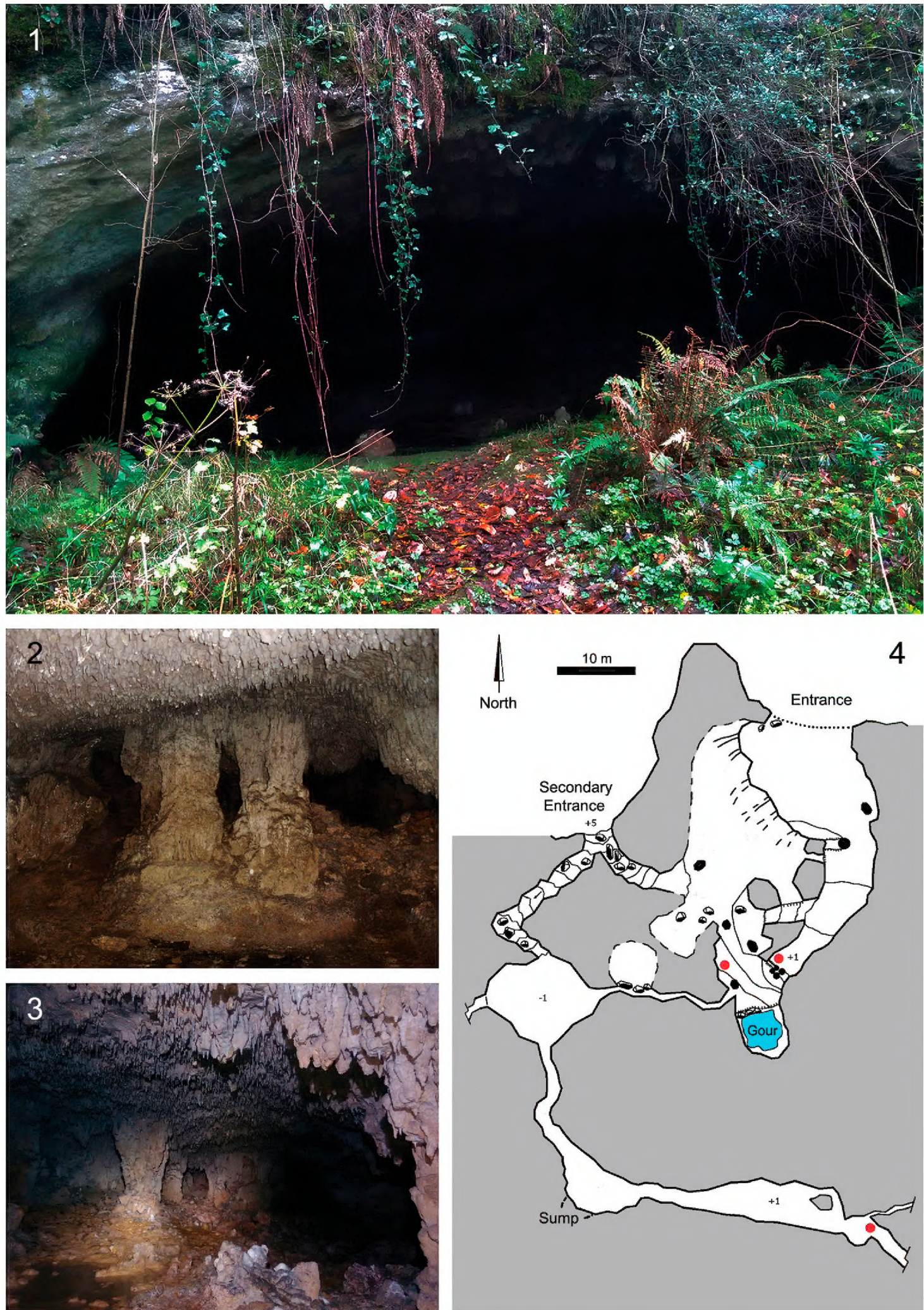


Figure 1. Cueva de La Herrería. Main entrance (1), two views of the *Zospeum* biotope (2, 3) and cave plan (4) (red dots: *Zospeum* sites). Photos and plan: S. Quiñonero-Salgado / A. Alonso.

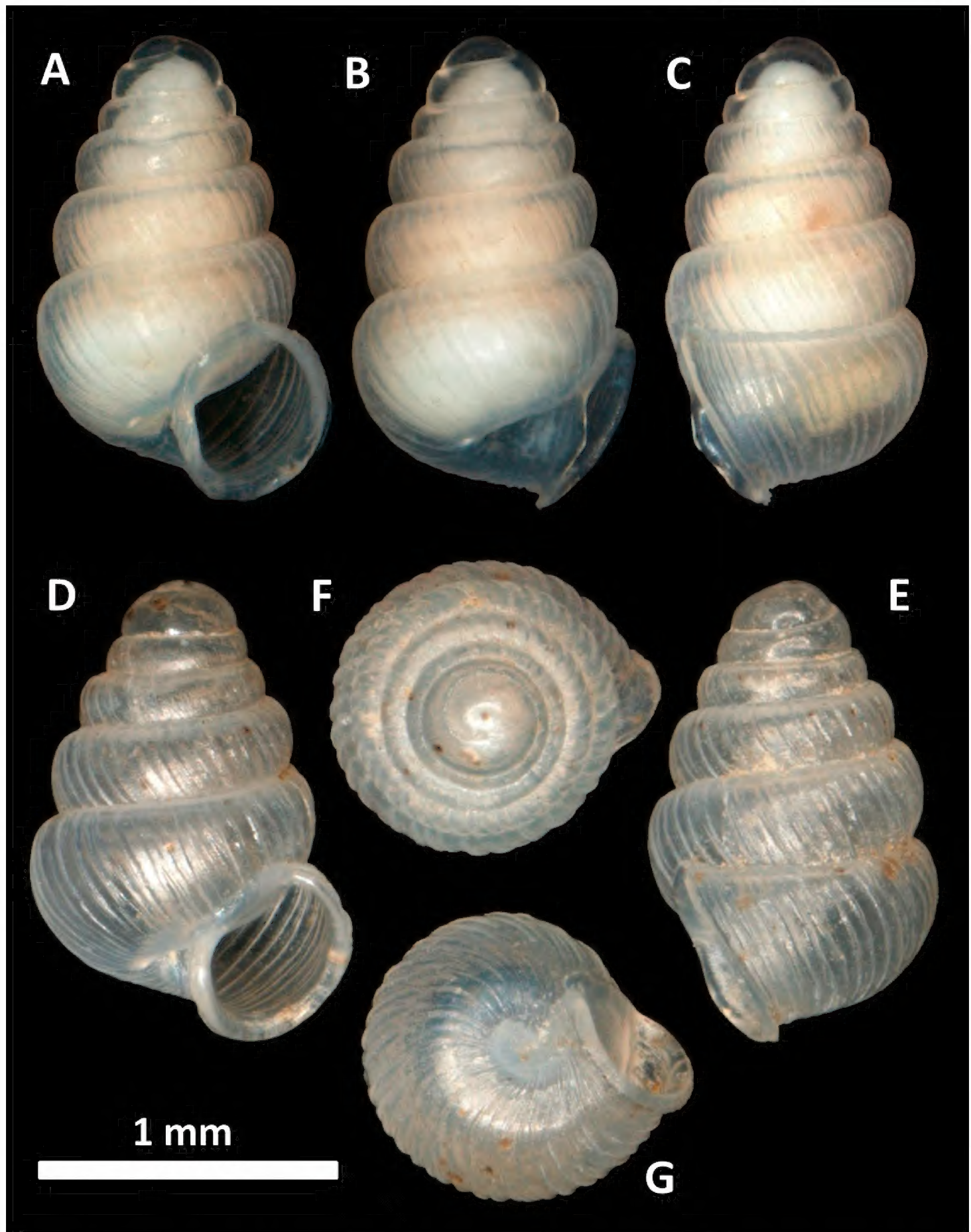


Figure 2. *Zospeum percostulatum* sp. n. Different views of the holotype (**A–C**) and a paratype 1.58 mm height (**D–G**). Note the inner whitish/yellowish mass in the holotype corresponds to their soft parts and the different orientation of the longer aperture axis between **A** and **D**.

rounded outer edge and parietal edge delineated by a parietal callus, thickened in more stylized shells. Peristome reflected, sometimes bilabiate, and thickened, especially in the columellar border. Last whorl without internal formations, with cylindrical colu-

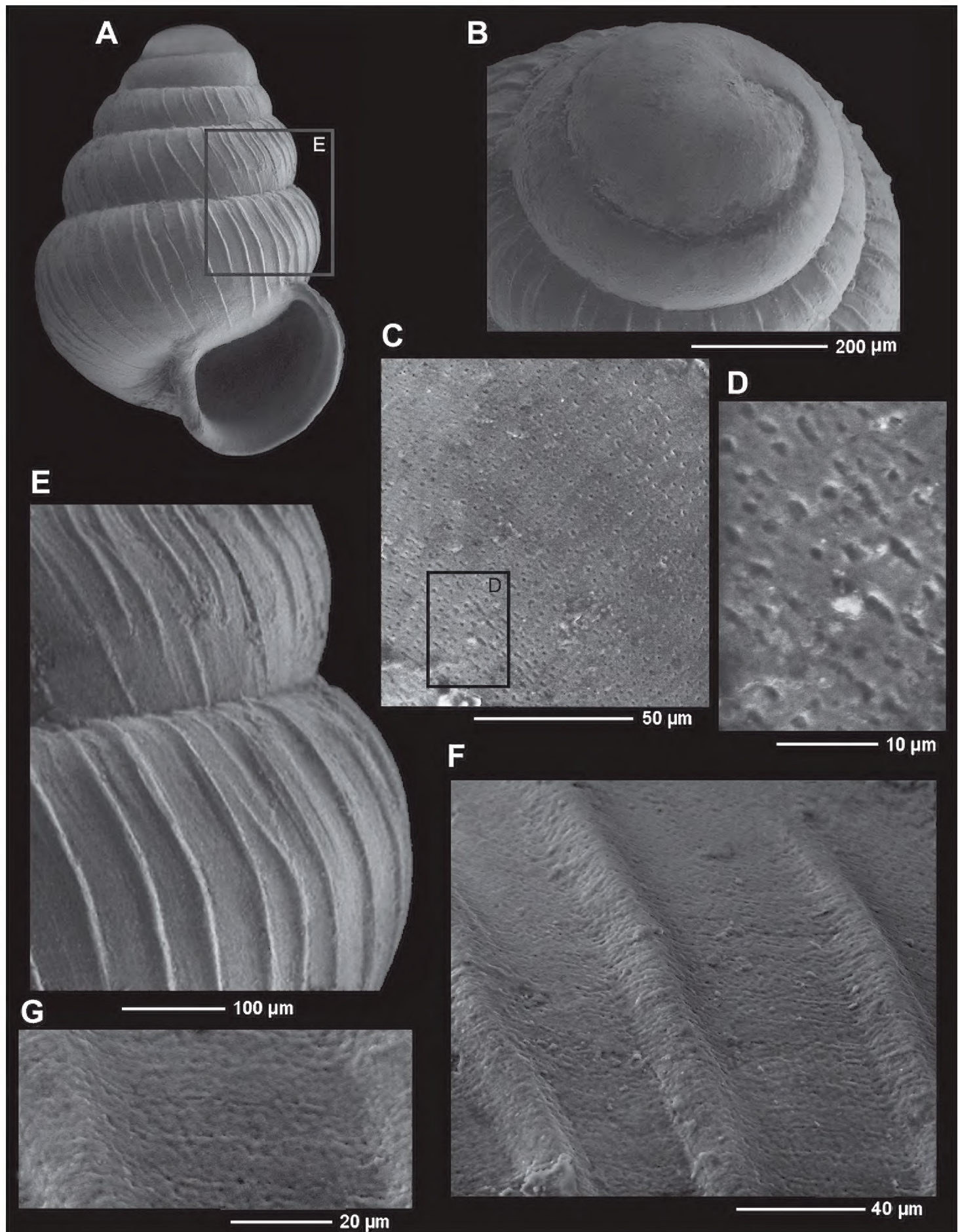


Figure 3. *Zospeum percostulatum* sp. n. Frontal view of a paratype (**A**, 1.42 mm height) [MHNS] and some partial views (**B–G**): **B** protoconch **C** microsculpture of the protoconch **D** detail selected in **C** **E** suture and costulae of the last whorl **F** shape of costulae **G** microsculpture of the teleoconch.

mella, 0.15 mm in diameter. Umbilicus shallow, with imperceptible umbilical groove. Shell surface seems smooth, but irregular longitudinal lines crossed with little marked spiral lines can be seen at high magnification (Fig. 3F–G).

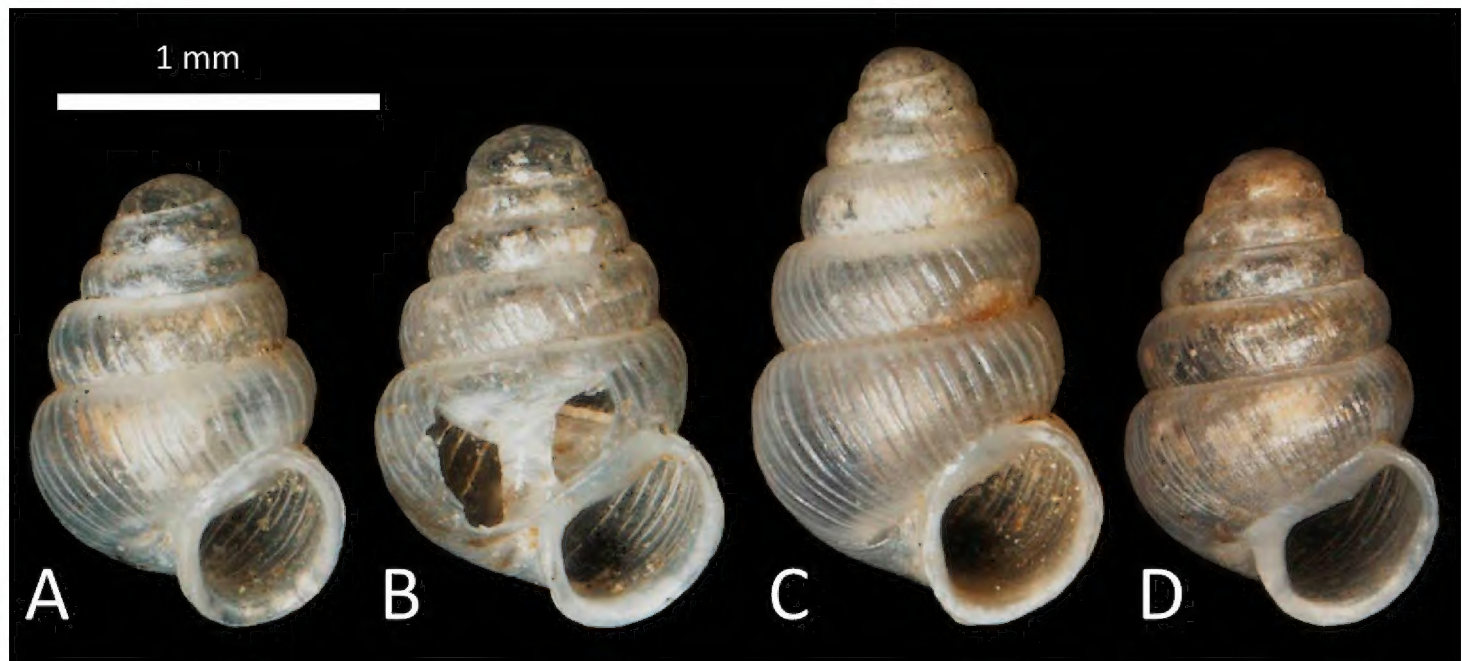


Figure 4. *Zospeum percostulatum* sp. n. Frontal views of three paratype shells (**A–C** 1.41, 1.80, 1.58 mm) and a shell from Cueva Collubina (**D** 1.49 mm) [ZUPV]. Note the robust, smooth columella through the window opened in the body whorl (**C**) and closer, smaller riblets in **D**.

Dimensions. The holotype shell measures 1.59 mm height and 1.00 mm width (Fig. 2A–C), and the body whorl reaches 58 % of the shell height. Morphometric data from the type locality and Cueva Collubina (Table 1, Fig. 5) indicate that both populations are somewhat distinct, being formed the later by somewhat smaller individuals with more closer riblets per whorl.

Etymology. The specific epithet refers to the ribbed surface of the shell in diminutive ('costulata') with the Latin prefix 'per-' (meaning 'very') to emphasize the best diagnostic character with regard to the remaining Iberian species.

Habitat. Strict troglobiont living on wet, concretionated cave walls covered by a clay film, although it can also be found on the ground, under concretion fragments. Some shells were collected at only 35 m away from the cave entrance. Empty shells are much more abundant than live individuals, which are much harder to find because their transparent shell and light cream color camouflages them with clay and concretions. Due the absence of decalcification in empty shells, these can last a long time (perhaps centuries) and accumulate by hundreds in a litter of clay sediments at the foot of cave walls. This species shares its biotope with a distinctly smaller *Zospeum* species belonging to a conchological *suaresi* species group (see Discussion) although a topographical differentiation cannot be discarded. More external sites for *Zospeum* in Cueva de la Herrería (Fig. 1) mostly provided *Z. percostulatum* sp. n., with only a few empty shells of *Z. cf. suaresi*, whereas the most internal site provided all found living snails of this last species, many individuals in close vicinity on corrugated patches of clay, as depicted by Jochum et al. (2012: Fig. 2), but only a few empty shells of the larger *Z. percostulatum* in a proportion of 10:1. A similar microtopographical distribution has been observed in other caves from the Basque region (C. Prieto, unpub. obs.) where the smaller species concentrates on clay patches and the larger species wander lonely on stalactites and concretionated walls.

Table 1. Conchological parameters of populations of *Zospeum percostulatum* sp. n. from the type locality and Cueva Collubina. SH, shell height; SW, shell width; BWH, body whorl height; AH, aperture height; AW, aperture width; WN, whorl number. Measurements in mm except WN.

		SH	SW	BWH	AH	AW	WN
Cueva de LA HERRERIA (n=32)	HOLOTYPE	1,594	1,000	0,920	0,606	0,541	5,550
	min	1,403	0,954	0,859	0,538	0,504	4,900
	max	1,803	1,123	1,006	0,637	0,621	5,750
	mean	1,574	1,040	0,926	0,595	0,555	5,394
	st.dev.	0,097	0,044	0,034	0,026	0,025	0,224
Cueva COLLUBINA (n=10)	min	1,340	0,909	0,798	0,478	0,520	5,150
	max	1,554	0,997	0,926	0,575	0,588	5,500
	mean	1,452	0,968	0,857	0,550	0,549	5,343
	st.dev.	0,069	0,025	0,044	0,037	0,023	0,140

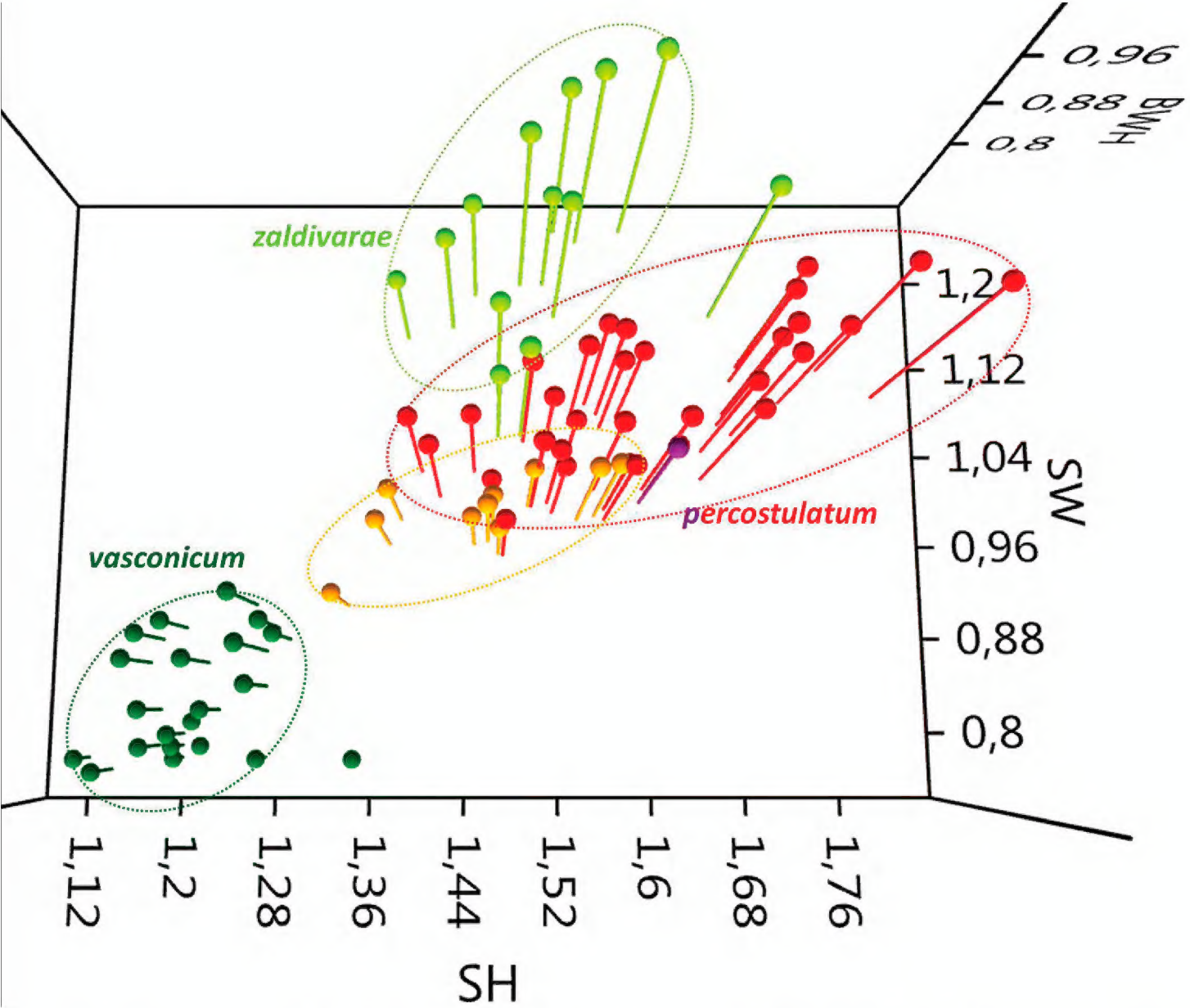


Figure 5. Tridimensional plot of main conchological parameters (SH, SW and BWH) of *Zospeum vasconicum*, *Z. zaldivarae* and *Z. percostulatum* sp. n. (data in Excel files of C. Prieto). Note the holotype (violet dot) and the smaller shells from Cueva Collubina (orange). Note also that a large shell of *Z. zaldivarae* (described in Prieto and Gómez 1985) and a slender, teratological shell of *Z. vasconicum* lie outside their circumscribing ellipses.

Regarding the biocoenosis of the cave, no other strict troglobiont gastropods (i.e. *Cryptazeca*) were found, and only some common species like *Oxychilus* sp. or *Elona quimperiana* (Blainville, 1821) seem to live inside. Other troglobiont species are the coleopterans *Laemostenus peleus* (Schaufuss, 1861), *Breuilia triangulum* (Sharp, 1872) and *Quaestus occidentalis* (Jeannel, 1911) (Jeannel and Racovitza 1915; Español 1954; Collado 1977). Jeannel and Racovitza (1915) recorded the finding of springtails, diplopods and isopods but apparently they were never published.

Distribution. *Zospeum percostulatum* sp. n. has been found in two caves 3.5 km far away from each other, placed in the lower part of northern foothills of Sierra de Cuera (Fig. 6). This sierra, a calcareous east-west formation of about 25 km in length and up to 1315 m high, not yet investigated for the genus *Zospeum*, is separated from the Picos de Europa by the Cares river, on whose northern foothills are placed the caves cited for *Z. suarezi* and *Z. schaufussi*. The distance between these caves and those inhabited by *Z. percostulatum* sp. n. is about 12–15 km.

Discussion

Shell morphology alone cannot be seen as sufficiently informative for recognizing microgastropod species of *Zospeum*, at least in certain species-groups, as was evidenced by Weigand et al. (2013) by identifying four genetic lineages having shells like *Z. suarezi* (but see e.g., Jochum et al. 2015b). Although more integrative evidence as anatomical or molecular data is desirable, the description of new clearly recognizable taxa cannot be hindered by arguing the absence of genetic data, which is the rule for most of marine or other subterranean micromolluscs, inclusively with the erection of supraspecific taxa (e.g., Jochum et al. 2015a). As *Zospeum percostulatum* sp. n. is the only one Iberian species with ribbed shell, the possibility that future genetic analyzes do not confirm their uniqueness is unlikely.

The two westernmost Iberian species, *Z. schaufussi* and *Z. suarezi*, have been recorded for Asturias in two nearby caves from Cabrales, both from Cueva de Inganzo and the later also from Cueva de los Quesos (Gittenberger 1980). Strikingly, Gittenberger (1980) drew the unique published sketch for each species from shells from Cueva de Inganzo, being in fact the conchological reference for both species. However, considering that the type locality of *Z. suarezi* is 70 km far eastward, that there are four (at least) cryptic species with similar conchological features (Weigand et al. 2013) and that the description of Frauenfeld (1862) for *Z. schaufussi* does not match with Gittenberger's drawing and description, the true identity of Asturian records is doubtful. Therefore, *Zospeum percostulatum* sp. n. can be considered the first unequivocal Asturian species.

Zospeum percostulatum sp. n. has been found syntopically with another *Zospeum* species having a smaller size, conical shell with well convex whorls, smooth surface, round aperture with continuous peristome and inner columellar lamella which pokes at the opening. These conchological features allow ascribing this second species to a species group, which would be integrated, at least, by the four genetic lineages evidenced by

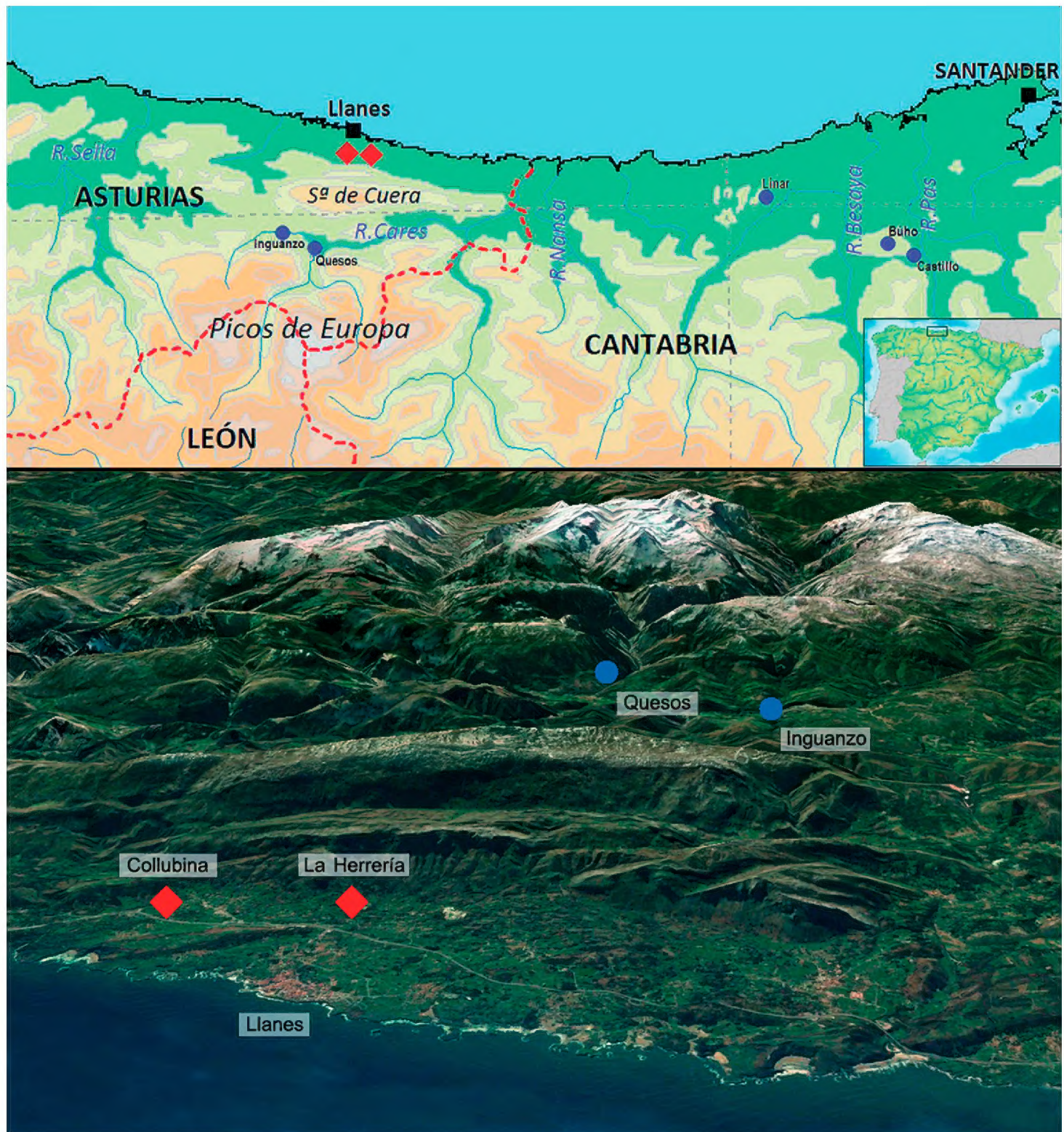


Figure 6. Map (above) and virtual aerial view (below, from the North) with mentioned caves for Asturian-Cantabrian *Zospeum* species: *Z. percostulatum* (♦); *Z. schaufussi* / *suarezi* (●). Map made with Dmap; aerial view of Digital Globe (screen shot of Google Earth).

Weigand et al. (2013) and cited as *Zospeum suarezi*. They recognized that the populations of Bosque (Inguanzo), Linar (La Busta), Las Paúles and Los Cuervos (Bizkaia) caves represent different species with a similar conchological morphology. This *suarezi* species group includes also another genetic lineage for populations from eastern Bizkaia and western Gipuzkoa caves, which were conchologically recognized as a new undescribed species by Altonaga et al. (1994) many years before its description as *Zospeum vasconicum* (Jochum et al. 2015c). For the moment, due to the complexity of this open question, which increases with nomenclatorial aspects related to *Z. schaufussi*, we do not address the issue of the identity of this companion species.

No graphical representation of the conchological morphospace occupied by *Zospeum* species has been yet published. As exposed before, Alpine-Dinaric taxa would constitute a monophyletic clade (Weigand et al. 2013) much more diverse than the Pyrenean-Cantabrian sister clade. Apart from tripling the number of known species, some of them have no conchological counterpart in the Iberian Peninsula, as *Z. spelaeum costatum* (Freyer, 1855), a large, strong ribbed species showing a carychioid facies, with well developed lamellae reaching the apertural plane, and also palatal teeth. On the contrary, *Z. biscaiense* with two apertural parietal lamellae, two palatal teeth and without inner lamellae (Gómez and Prieto 1985) has no counterpart in Alpine-Dinaric taxa.

Some *Zospeum* species of the Alpine-Dinaric region present a wide variability as shown by Bole (1974) or Pezzoli (1992), both in sculpture and development of aperture formations as well as in size and diameter, being obviously greater in species with wider geographic range. Thus, Pezzoli (1992) gives a size range for *Z. globosum* of 1.2–2.2 mm, even with some cavities in which two clearly distinguishable morphologies are present (eg. Grotta del Soglio: standard shape, 1.6–1.7 mm and turreted shell, 2–2.1 mm). Such wide variability has not been described for any Iberian species although Gittenberger (1980) cites a size of 1.3–1.9 mm for *Z. bellesi*.

The presence of conspicuous and prominent axial ribs constitutes a taxonomic character that until now has not been indicated for Iberian species, so *Z. percostulatum* sp. n. can be differentiated immediately from all of them. Furthermore, this new species fills one of the conchological gaps – the lack of ribbed species – between Alpine-Dinaric and Pyrenean-Cantabrian taxa. Occasionally, some shells of the known Iberian species have some stronger streaks, especially under the suture, taking the aspect of incomplete riblets but in *Z. percostulatum* sp. n. ribs form a constant and regular pattern. In addition, the new species has relatively large shells, reaching 1.8 mm length, in comparison to the other Cantabrian species, whose largest shells barely reach 1.45 mm height (Gittenberger 1980), making its recognition and discrimination easier.

In Cueva Collubina, 3.5 km eastward from the type locality, we have found shells attributable to *Z. percostulatum* sp. n., but they are somewhat smaller and wider, with more auriculate aperture, thinner parietal callus and finer and tighter ribs. Although they could be minor differences linked to geographical isolation, we consider that these individuals belong to the same species.

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